Appendix

Instrumental Variable Analysis

A secondary analysis was carried out to estimate the relationship between the overall quality score and mortality using an instrumental variable technique. This is a quasi-experimental methodology and utilises variations in care which result in patients being randomly allocated to different treatments or exposures. By making use of such "natural experiments", the technique can reduce errors caused by unmeasured confounding in a manner akin to randomisation in a controlled trial[1]. As the instrumental variable we used the Acute Domain Organisational score measured in the 2010 Sentinel Audit. The validity of the instrumental analysis rests on a number of key assumptions:

1) That patients are randomised at the hospital level and that there is no relationship between the organisational score of the admitting hospital and patient level prognostic factors. We tested this assumption, and the extent to which the instrumental variable reduced confounding, by comparing the balance of observed patient level variables between levels of quality score and organisational score [see Table 5 in full paper]. We also tested whether there was evidence of systematic bias in the propensity of hospitals to identify patients as being ineligible to receive all six processes of care included in the quality score. This was done by fitting multilevel models to estimate the odds of being identified as ineligible for the all six processes in the quality score, including levels of organisational score and patient level characteristics as covariables in the model. Six of the patient characteristics were significantly associated with ineligibility: Requirement for oxygen therapy (OR 1.46, 95%CI 1.37- 1.56), arm weakness (OR 0.90, 95%CI 0.84-0.98), dysphasia (0.94, 95%CI 0.89-0.99), hemianopia (1.33, 95%CI 1.36-1.41), increasing age (OR 0.99 per year, 95%CI 0.99-0.99), reduced consciousness (OR 2.29, 95%CI 2.23-2.54) and functional dependence pre stroke (OR 0.76, 95%CI 0.71-0.81). None of the four quarters of organisational score were significantly associated with eligibility; nor was the acute domain score included in the model as a continuous variable.

2) That the stroke service organisational score is correlated with the quality score of patients admitted to each service. Low correlation (a "weak" instrumental variable) results in standard errors too large for meaningful inference[1]. The relationship between organisation score and quality score was estimated using a multilevel binary logistic model to account for clustering at the hospital level [see Figure 2 in full paper]. We also estimated a first stage Cragg-Donaldson F statistic of 1668 in a linear two stage model estimating quality score from the organisational score, indicating a non-weak instrumental variable[1].

3) That the instrumental variable is independent of the outcome and is only associated with it via the measured quality score, and not, for example, through a generic effect of stroke service organisation on mortality. It is not possible to formally test this assumption directly, but we tested this indirectly by estimating the association between the organisation score and mortality, controlling for quality score, in univariable analysis and in a multilevel multivariable logistic model [see Table 6 in full paper and the Table 1 below].

For the instrumental variable analysis, coefficients and standard errors were estimated using a simultaneous bivariate probit model as demonstrated in previous studies[2-4].The model included the same covariates as the multivariable regression models described above and the organisational score was categorised by quartiles. In order to aid comparison with odds ratios derived from the logistic regression models, the coefficients of the bivariate probit models were estimated as odds ratios using a scale factor of 1.6[4 5].

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4 Rassen JA, Schneeweiss S, Glynn RJ, Mittleman MA, Brookhart MA. Instrumental variable analysis for estimation of treatment effects with dichotomous outcomes. *Am J Epidemol* 2009;169:273-84.

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		30 day mortality (%)				
Quality score		**Quarters of stroke service organisational score**				
	n	1(Lowest)	2	3	4 (Highest)	p
0-4	13,812	9.1	10.4	8.2	9.8	0.13
5-6	11,964	5.6	5.2	6.8	5.9	0.062

Table 1. Crude 30 day mortality rate by quarters of stroke service organisational score and quality score